High-Tech Soil Erosion Survey

- **For Camp Guernsey, Wyoming**

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Military Training vs. Natural Resources

- Maneuver
- Tracked Vehicles
- Soil Compaction
- Munitions
- Emplacements
- Fires
- Herbaceous vegetation
- Woody vegetation
- Soils Loss
- Drainage Problems
- Sediment

Potential Off-site Impacts ?

- You bet. As much as 92% of suspended sediments in waterways nationally is attributable to non-point sources.
- Eutrophication
- Risk of downstream flooding
- Fisheries
- Lake/reservoir storage capacity
- Costs up to $9 billion/year in U.S.

Soil Erosion Serious Issue at Camp Guernsey

- So, we wanted to…
- 1) Identify specific areas that are now contributing to excessive soil erosion, or
- 2) Are likely to contribute to excessive erosion in the future if training alters or eliminates vegetative growth

Study Area

- Camp Guernsey is located in southeastern Wyoming along the North Platte River in Platte County
- It is approximately 25 miles northeast of the town of Wheatland and 33 miles west of the town of Torrington.
- It consists of 35,000 acres with a 7,000-acre impact area and 24,000 maneuver acres.

Primary Mission

- To provide a **major training area** and **logistic support** for **Annual Training** (AT) and **Inactive Duty Training** (IDT) while maintaining military readiness for the Wyoming Army National Guard and Air National Guard units and to provide year-round training to other military units that utilize the facilities offered at Camp Guernsey.

Climate

- Semiarid, with a total annual precipitation of 13 in. Peak precipitation usually occurs in May and June. Average daily temperatures range from 30.5° F in the winter to 69.8° F during the summer.

Topography

- The elevation ranges from 4300 to 5,280 feet above sea level. Rolling hills with scattered rock outcrops are typical.

Soils

- STA - shallow to moderately deep loamy and sandy soils with many areas of rock outcrops.
- NTA - deep to moderately deep silty and loamy soils found on gentle to moderately steep rolling hills.
- For the most part, soils are well to excessively drained.

Erosion Modeling

- Most widely used models:
- Universal Soil Loss Equation (USLE)
- Revised Universal Loss Equation (RUSLE)
- both applicable where erosion is limited primarily by the ability of rainfall and runoff to detach soil particles (detachment limited) & account for the effects of topography based solely on slope length and steepness.

Erosion Modeling

- For Camp Guernsey we selected the Unit Stream Power Erosion and Deposition model (USPED), a multidimensional derivative of the USLE that is applicable to complex terrain and is best applied where erosion is limited by the ability of runoff to transport sediment (detachment capacity exceeds transport capacity, or is transport limited).

Universal Soil Loss Equation

- E = R *x* K *x* LS *x* C *x* P
- where R = erosivity due to rainfall & runoff
- K = inherent soil erodibility
- LS = slope length & steepness
- C = vegetative cover
- P = conservation support practices

Unit Stream Power Erosion and Deposition model (USPED)

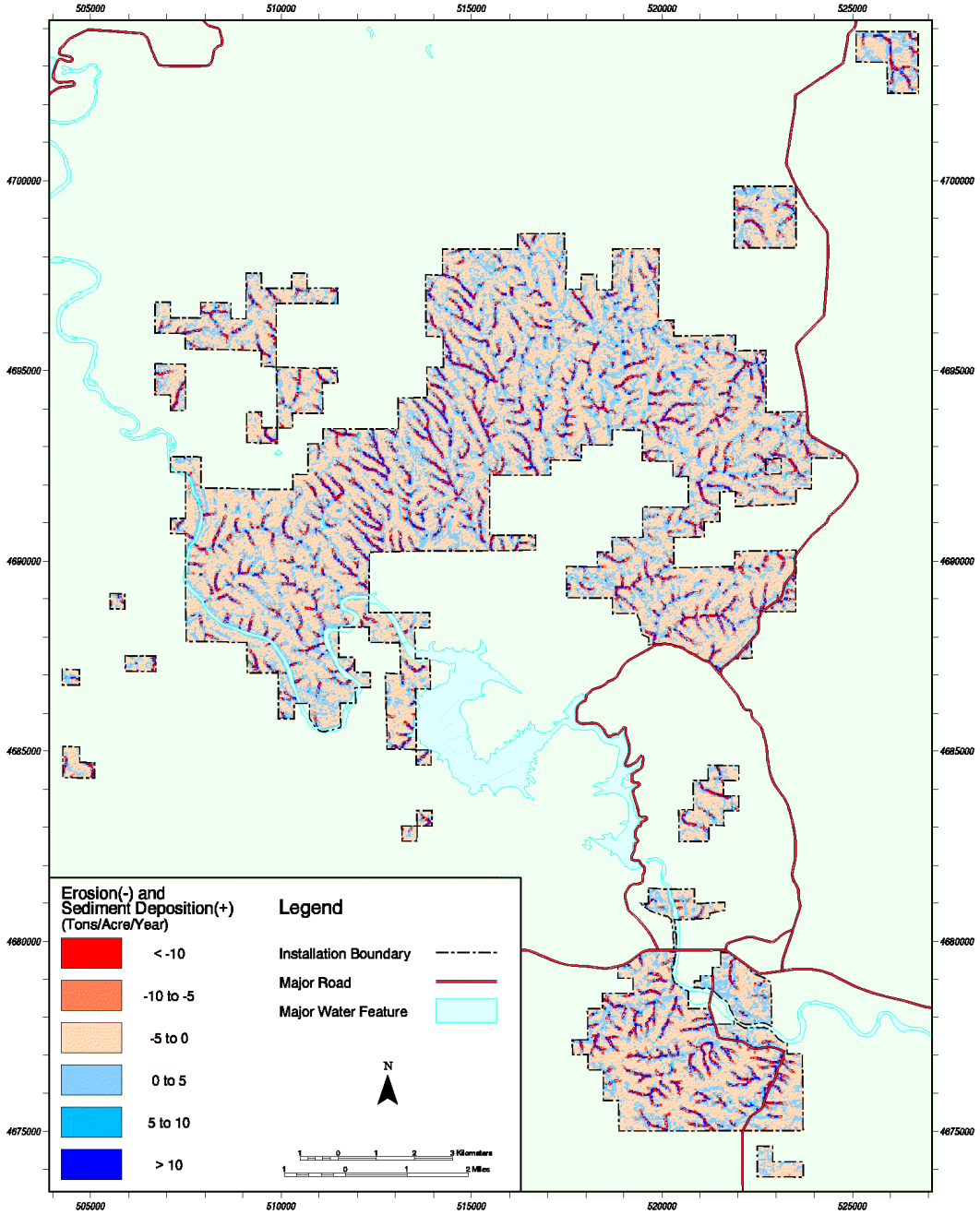
- Substitutes an LS analog:
- $LS = A^m (\sin B)^n$
- where A = upslope contributing area
- B = slope angle
- m,n = constants dependent on type of flow and soil properties:
- where rill erosion dominates: m=1.6, n=1.3
- where sheet erosion dominates: m=n=1.0

USPED Model (continued)

- To compute both Erosion and Deposition (ED) as a change in sediment transport capacity across a GIS grid cell, a further computation is performed:
- $ED = \frac{d\,(E\cos a)}{dx} + \frac{d\,(E\sin a)}{dy}$
- where a is slope aspect in degrees in the direction of steepest slope

Results

- Multiplying component data layers together on a cell by cell basis produced a data layer showing the spatial distribution of soil erosion and deposition at Camp Guernsey.
- This predicted value layer shows the majority of the Camp experiencing soil erosion at a rate of less than 5 tons acre^{-1} year^{-1}, roughly equivalent to 1 millimeter per year.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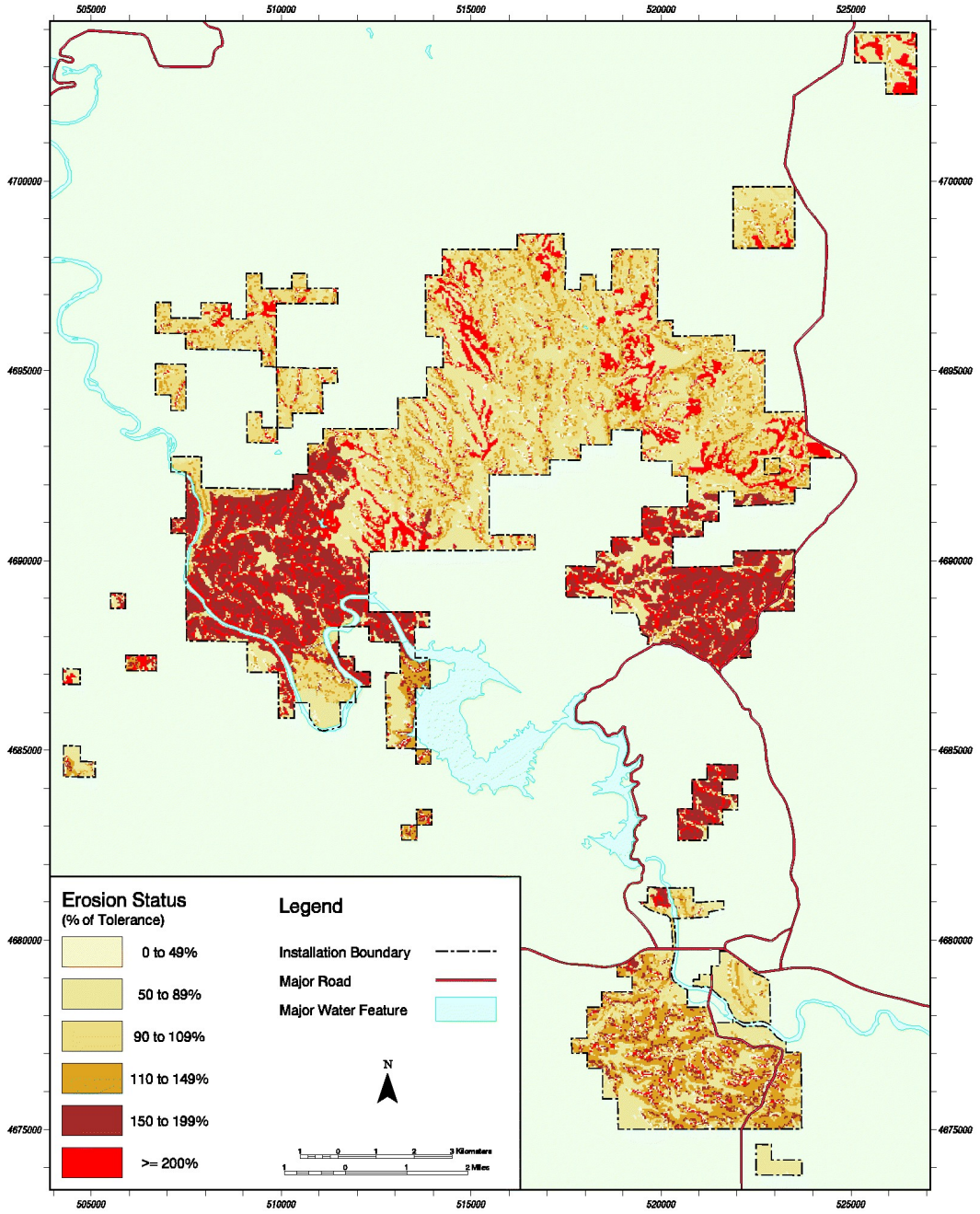
Erosion(-) and Sediment Deposition(+) (Tons/Acre/Year)
< -10
-10 to -5
-5 to 0
0 to 5
5 to 10
> 10
Legend
Installation Boundary
Major Road
Major Water Feature
N
3 Kilometers
2 Miles

Results

- By itself, an annual estimate of soil erosion and deposition is of little practical value in land use planning. A ratio of estimated soil loss to soil loss tolerance, or **Erosion Status** (ES) is a more accurate index from which to evaluate the condition of the land and on which to base land management decisions:
- $ES = \frac{(R \times K \times LS \times C \times P)}{T}$ where: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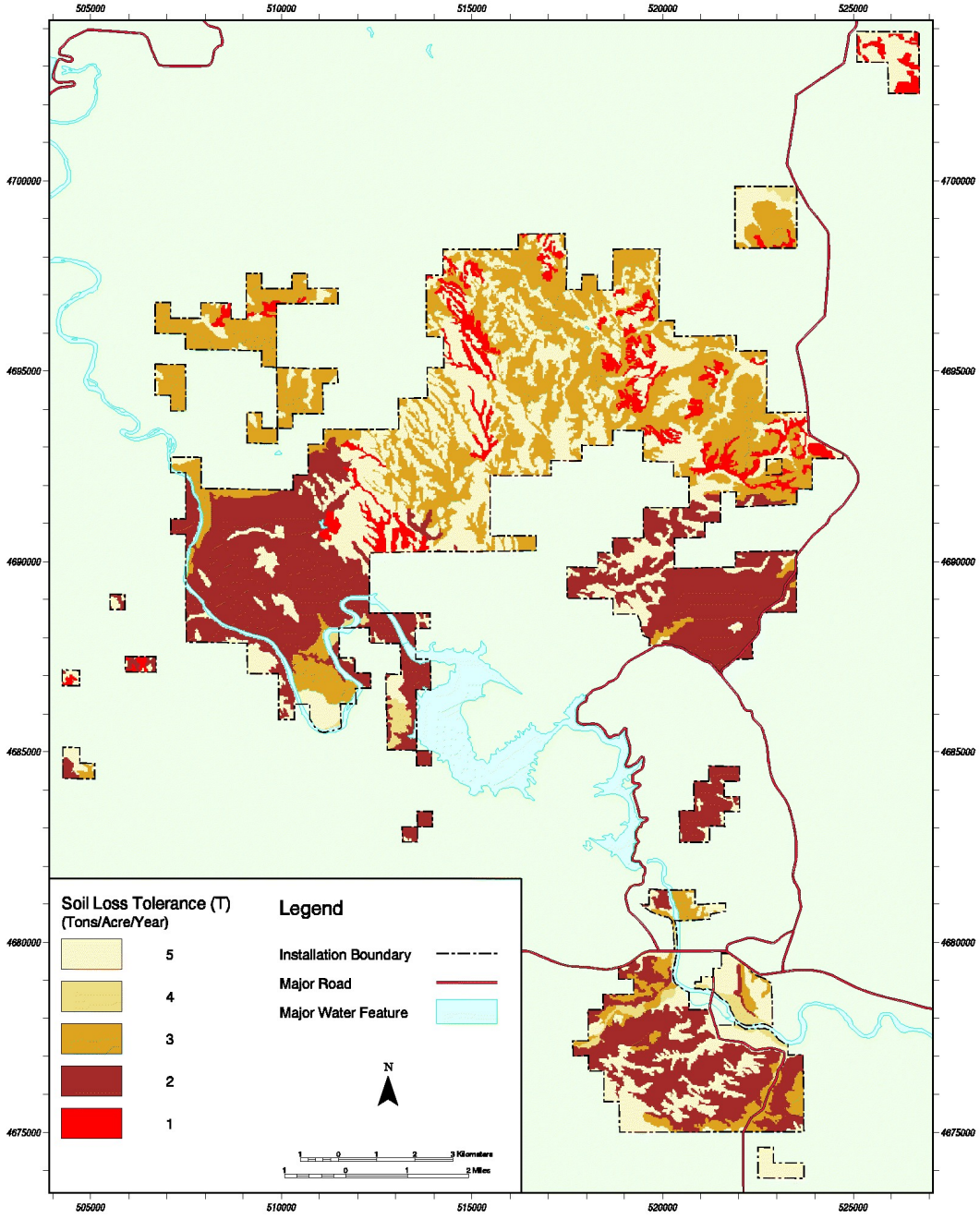
Erosion Status
(% of Tolerance)
0 to 49%
50 to 89%
90 to 109%
110 to 149%
150 to 199%
>= 200%
Legend
Installation Boundary
Major Road
Major Water Feature
N
3 Kilometers
2 Miles

Results

- The T factor is an expression of soil loss tolerance, or the amount of soil erosion that can be sustained on an annual basis without causing significant reductions in long-term plant productivity. It is dependent on intrinsic rates of soil formation and soil depth. A T-factor data layer was produced using soil survey data.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Soil Loss Tolerance (T)
(Tons/Acre/Year)
5
4
3
2
1
Legend
Installation Boundary
Major Road
Major Water Feature
N
3 Kilometers
2 Miles

Results

- A soil erosion status map was created by performing calculations on a cell-by-cell basis for the entire installation and reclassed into six categories, each reflecting a range of erosion status values.

USPED Prediction - Erosion/Deposition

Erosion/ Deposition Categories	Acres	% Area
>10 tons/ac/yr Erosion	1657	5
5-10 tons/ac/yr Erosion	618	2
0-5 tons/ac/yr Erosion	23443	70
0-5 tons/ac/yr Deposition	6138	18
5-10 tons/ac/yr Deposition	398	1
>10 tons/ac/yr Deposition	1389	4

USPED Prediction - Soil Erosion Status

Soil Erosion Status (% of tolerance)	Acres	% Area
0-49 %	1409	4
50-89 %	9835	29
90-109 %	7467	22
110-149 %	4555	14
150-199 %	6311	19
≥199 %	4004	12

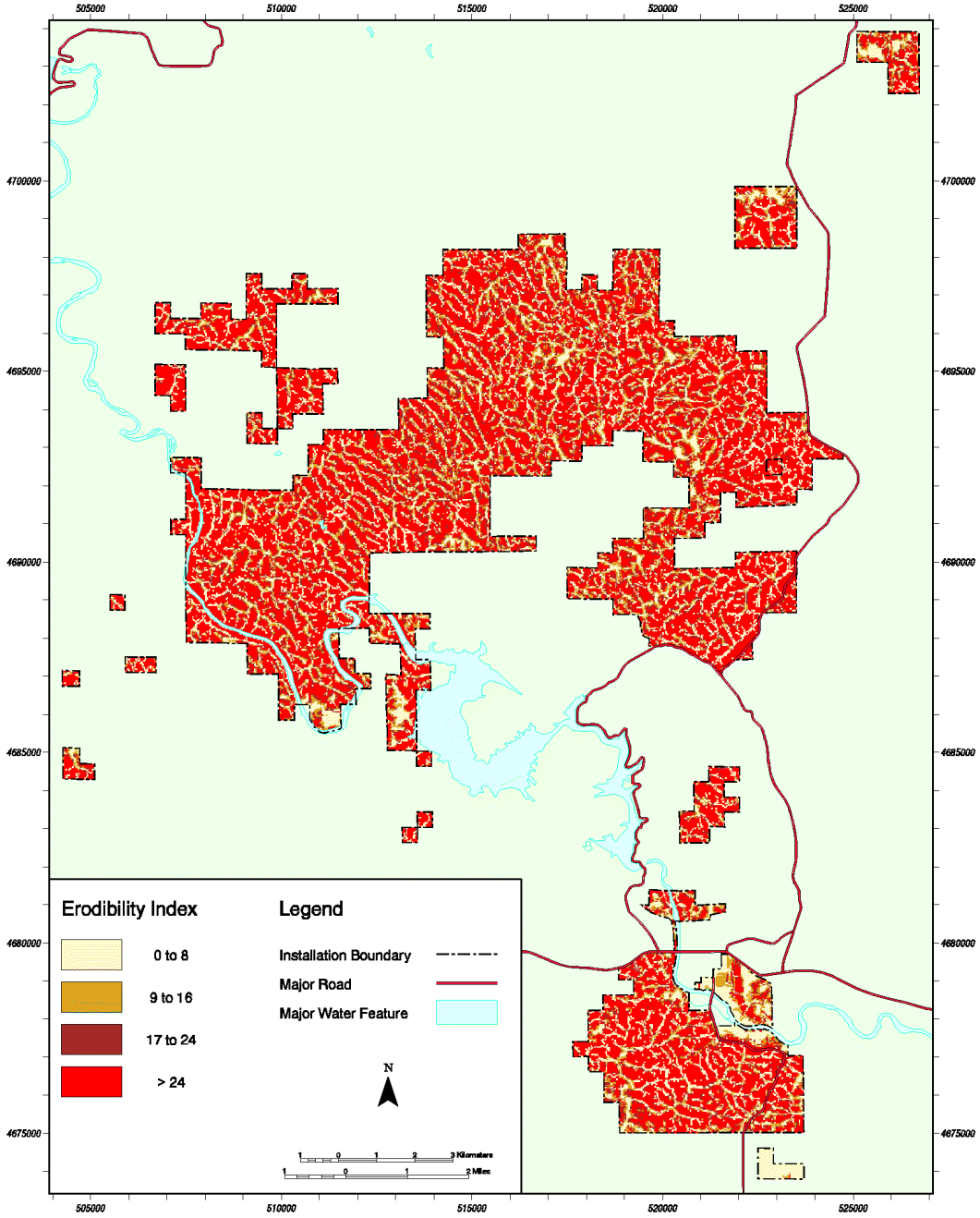
Erodibility Index

- Another variable of interest is the inherent erosion potential or Erodibility Index (EI) and can be calculated as

$$EI = \frac{(R \; x \; K \; x \; LS \; x \; P)}{T}$$

USPED Prediction - Erodibility Index

Erodibility Index	Acres	% Area
0-8	6929	21
9-16	2542	7
17-24	2953	9
>24	21284	63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4675000
Erodibility Index
0 to 8
9 to 16
17 to 24
> 24
Legend
Installation Boundary
Major Road
Major Water Feature
N
Kilometers
Miles

USPED model prediction

- Based on field validation, the USPED model produced erosion/deposition estimates that were consistent with the field observations 76% of the time.

147 IF
C-21

Erosion

Maneuver Damage

Questions ?